Photosynthetic Characteristics of Ash and Larch in Mixture and Pure stands

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Abstract The photosynthesis of ash (*Fraxinus mandshurica*) and larch (*Larix gmelini*) in pure and mixture plantation stands was measured and the influence of the microclimate on the photosynthesis was analyzed in this study. The result shows that the net photosynthetic rate (NPR) of ash is higher in mixed stand than in pure one, 61.64% higher in the measuring day. The NPR of larch is approximately the same in the two stands. The microclimate in the mixed ash --larch stand is much different from that in the pure one. The temperature is moderate in the mixture stand, e.g., the maximum temperature in the mixture stand is lower and the minimum temperature is higher than that in the pure ash stand. The relative air moisture is higher in the mixture stand. The microclimate in the mixture stand benefits the photosynthesis of ash, considered as one of the important reasons that make the mixture stand more productive.

Key words: Ash, Larch, Mixture plantation, Photosynthesis, Microclimate

Introduction

During the past two decades, studies have revealed that growing ash (*Fraxinus mandshurica*) and larch (*Larix spp.*) together in a proper way can increase the productivity of the stands[1,2,3,4]. The yield improvement mechanisms attribute to two aspects, i.e., the above ground and underground interspecific interactions. Forest stands, composed by different tree species, have different stand structures which influence the sunlight distribution, air temperature and humidity. The alteration of these factors may affect the photosynthesis of the trees growing in the stand without doubt. This study focuses on the photosynthetic characteristics of ash and larch in pure and mixture plantation stands and the microclimatic characteristics related to the photosynthesis in order to reveal the above ground reason that improving the yield of the mixture plantation forest.

Experimental Section

Study area

We conducted the measurement at the Maoershan Research Forest (MRF) of Northeast Forestry University. The experimental plantation forest was established in 1987. The spacing of the stand is 1.5m×1.5m. The mixture stand is composed by ash in 3 rows and larch in 5 rows. All the three stands for measuring are located in the strip cut bands(30m in width), between them, there are remnant second growth bands (25m in width) left during the strip cutting, The experimental plots were located at the downslope. One ash tree and one adjacent larch tree were chosen for measuring in the mixture stand. The other ash and larch trees were selected for measuring in the pure stands of each tree species, respectively. The experimental trees and the adjacent trees in the plots were measured, as in Table 1.

Table 1. Location and growth data of the experimental trees and adjacent trees

	Mixture satand					Pure ash stand				Pure larch stand					
	Measured tree	Adjacent tree				Measured tree	Adjacent tree			Measured tree	Adjacent tree				
Species	ash / larch	ash	larch	ash	ash	ash	ash	-	ash	ash	larch	larch	larch	larch	larch
Direction	-	E	S	W	W	-	E	S	W	N	-	E	S	W	N
H(m)*	5.86 / 6.88	4.42 / 6.52	6.08 / 6.81	5.82 / 7.33	5.07 / 5.86	4.44	3.15	-	2.63	3.65	6.65	7.40	6.79	6.34	6.00
Dc(cm)*	5.10 / 6.30	3.10 / 6.90	5.70 / 5.30	4.30 / 8.00	4.30 / 4.10	2.9	2.20	-	1.80	2.20	5.50	7.20	5.10	5.90	5.70

*: The uper dash data are for the measured ash trees and its adjacent trees; the under dash data are for the measured larch tree and its adjacent trees

Methods

One leaflet of ash(twig for larch) in each direction(E, S, W, N) was chosen and the photosynthetic rate of which was measured by using the LI6400 portable photosynthesis meter. The measurement started at 7:00 a.m. and ended at 5:00 p.m.. The photosynthetic rate and the related physical factors were measured with three replications every one hour. The twigs of larch were picked off for measuring and calculating the leaf area. The microclimatic data engaged in the paper were measured in 1995 in the microclimate site in the same stands.

Results and Analysis

The analysis of the photosynthesis of ash and larch in pure and mixture stands

The photosynthetic rate of ash and larch in pure and mixture stands are listed in table 2.

Table 2. The Net Photosynthetic Rate of Ash and Larch, $\mu mol\ CO_2\ m^{-2}\ s^{-1}$

Stand	species	7	8	9	10	11	12	13	14	15	16	17
mixture	ash	14.66	16.00	20.77	16.69	18.35	15.48	11.05	10.04	7.85	7.15	3.37
	larch	11.40	3.79	3.88	2.94	3.50	2.27	0.80	1.59	2.47	1.45	1.60
pure	ash	6.61	6.89	10.55	10.80	9.31	8.56	9.44	10.89	5.77	4.67	3.97
	larch	4.15	3.48	4.70	3.90	1.90	0.80	2.10	2.70	2.10	2.50	2.20

The difference of photosynthetic rate between ash and larch The photosynthetic rate of the two tree species is quit different during the measuring day(Fig. 1). The net photosynthetic rate of ash is higher at any measuring time. The average NPR of the two species are 12.85 and 3.24 $\mu mol\ CO_2 \cdot m^{-2} \cdot s^{-1}$, respectively. The photosynthetic rate of the two species reached its maximum values at different time which is good for the utilizing of carbon dioxide at the same stand[5].

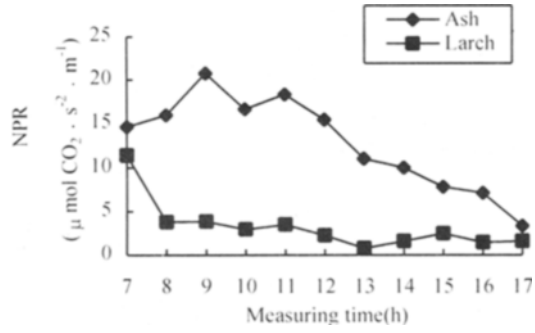

Fig. 1. The photosynthetic process of ash and larch in the mixture stand

The photosynthesis of larch in the pure and mixture stands Fig. 2 shows the photosynthetic rate of larch in the mixture and the pure stand . The NPR of larch tree in the mixture stand is quite close to that of larch in the pure stand, except that at 7:00 a.m.. The average NPR of larch in the mixture and pure stand is 3.44 and 3.32 $\mu mol\ CO_2 \cdot m^{-2} \cdot s^{-1}$. The photosynthesis of larch in the mixture stand was improved a little. The boundary effect may be considered to be the main reason[6].

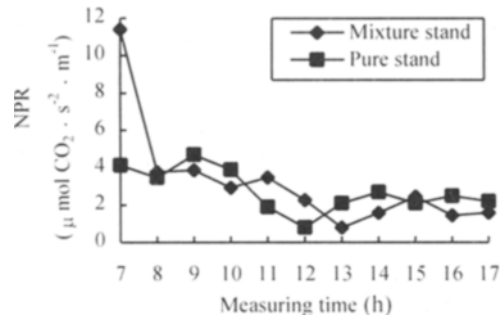

Fig. 2. The photosynthetic process of larch in pure and mixture stands

The photosynthesis of ash in the pure and mixture stands The day processes of photosynthesis of ash in the two stands are quite different. The NPR of ash in the mixture stand is higher than that in the pure stand in the whole measuring day except 2:00 p.m..The average NPR of ash in the two stands are 12.85 and 7.94 $\mu mol\ CO_2 \cdot m^{-2} \cdot s^{-1}$, respectively. The NPR of ash in the mixture stand is 61.64% higher than that in the pure stand. The higher photosynthesis ensure high productivity of ash in the mixture stand.

For more evidence to make sure that ash in the mixture stand is more efficient in solar energy converting, we measured the NPR of the leaflets of ash in different layers in the pure ash stand and the mixture stand at 5:00 p.m. when the light intensity is relatively stable. From Fig. 4 , we can see that most leaflets of ash in the mixture stand have higher NPR than that in the pure one, except the leaflets in the 3rd, 4th, 5th and 7th layers, the average NPR is 4.05 and 2.45 $\mu mol\ CO_2 \cdot m^{-2} \cdot s^{-1}$, respectively.

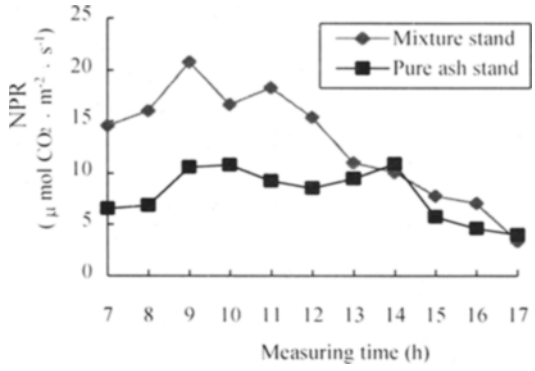

Fig. 3. Day photosynthetic process of ash in the two stands

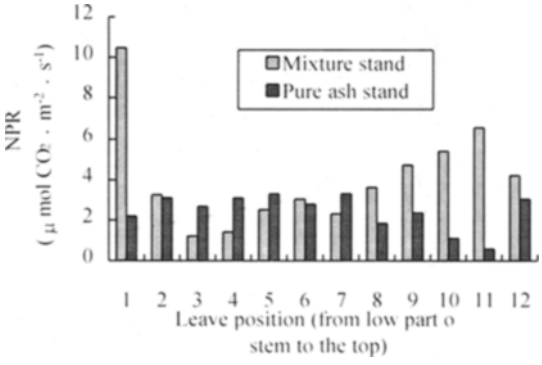

Fig. 4. The NPR of ash leaflets in different layers.

The effect on the photosynthesis of ash by the different vertical structure of the two stands The strip mixture stand and the pure stand have quite different vertical structure. The average height of ash trees is more than one metre lower than the adjacent larch trees, the later ones have formed side shade to the ash trees. Fig. 5 demonstrates the NPR of the leaflets of ash trees in the four directions(E, N, W, N) of crown in mixture stand. The average NPR of the leaflets in the four directions is 13.09 (E), 10.62 (W), 13.74 (S), 13.72 (N) μmol $CO_2 \cdot m^{-2} \cdot s^{-1}$, respectively. It is clear that the photosynthesis of side shaded leaflet (S direction) was not restrained by the shade.

Microclimate in the two stands and its effect on the photosynthesis of ash trees

Composed by different tree species, the mixture and the pure stand have different stand structure, hence the microclimatic difference. The different microclimate will effect on the photosynthesis of the trees.(J. P. Kimmins.1987)

Periodic mean temperatur and its dynamics Fig. 6 shows the periodic mean temperatrue in the mixture and pure ash stands. The two stands have the same temperature dynamic trend, the growth season mean temperature is 16.28 °C and 16.36 °C, respectively. The mean temperatur in the pure stand is little bit higher than that in the mixture one.

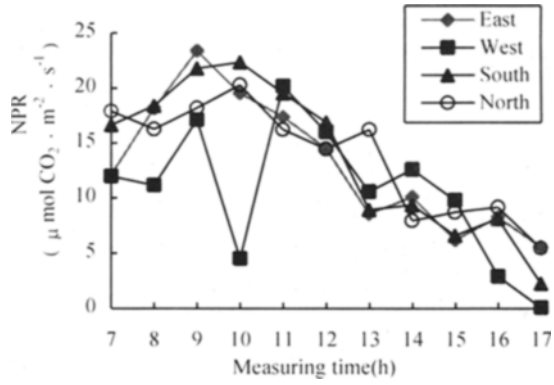

Fig. 5 The dynamic of NPR of the leaflets of ash in four direction

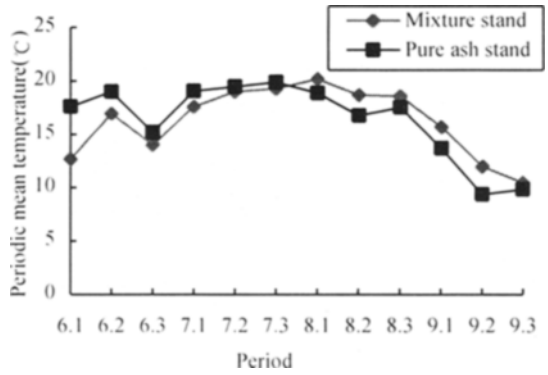

Fig. 6. The dynamics of periodic mean air temperature in the two stands

Fig. 7 and 8 show the periodic mean maximum and minimum air temperature and the dynamics. Before the end of June, the mean minimum temperature in the pure stand is higher than that in the mixture stand, and the values are 9.82 °C and 8.38 °C, respectively. But during the fast Growing season, the mean minimum temperature in the pure stand is much lower than that in the mixture stand, the values are 10.08 °C and 12.02 °C, respectively. The growing season mean minimum temperature shows the same trend, i.e. mixture > pure(11.87 °C and 9.22 °C). Fig. 8 demonstrates that the mixture stand has lower periodic mean maximum air temperature. The mean in the growing season is 21.21°C and 25.98 °C, respectively.

Mean air humidity and its dynamics Fig. 9 shows the periodic mean air humidity and its dynamics. The mixture stand has higher air humidity in almost all the measuring periods except the last third of June. The

growing season mean of the air humidity is 86.80% and 80.54%, respectively. The air in the mixture stand is much more humid than that in the pure stand.

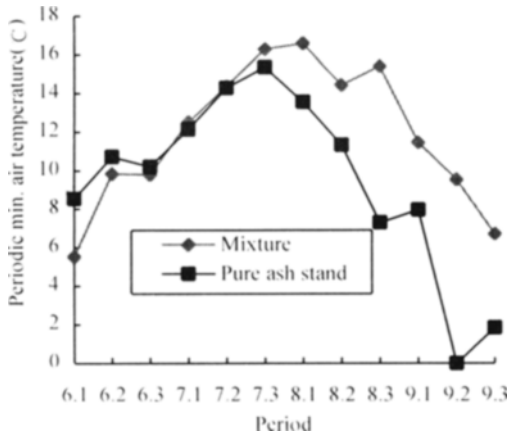

Fig. 7. The periodic minimum air temperature in the two stands

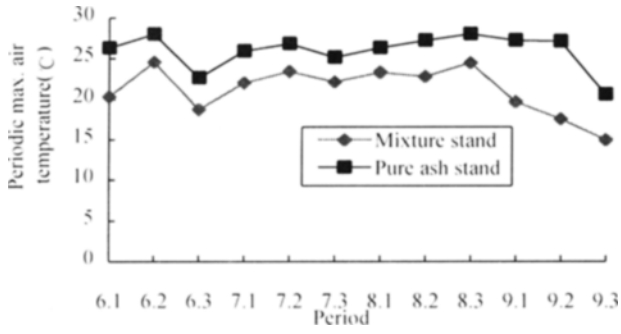

Fig. 8. The periodic maximum air temperature in the two stands

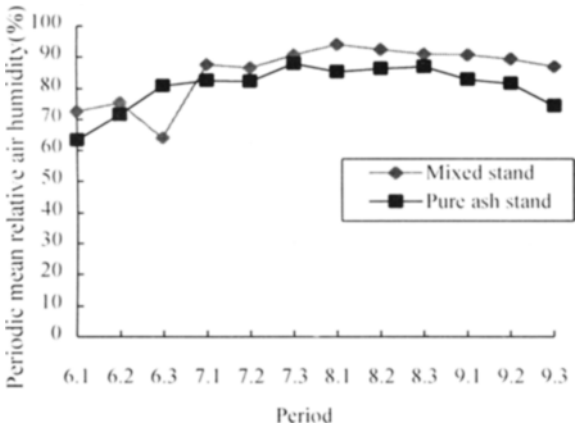

Fig. 9. The periodic mean relative air humidity in the two stands

From the above analysis, we can conclude that the microclimatic condition in the mixture stand was improved, the variation of air temperature was reduced and the air humidity was raised. The microclimatic condition in the mixture stand is more suitable for the photosynthesis of trees. This may deduced to be one of the important reason which stimulated the growth of ash in the mixture stand[8].

Conclusions

Ash trees are more efficient in photosynthesis in the mixture stand than in the pure stand. The NPR of ash tree in the mixture stand is 61.64% higher than that in the pure stand in the measuring day. The larch tree has the same photosynthetic efficiency in the two stands.

The mixture stands of ash and larch has different microclimate with the pure stand of ash. The mixture stand has humid air and more moderate air temperature which benefit the photosynthesis of ash.

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